APPENDICES A-E

Southern Hills Lakes Preliminary Evaluation and Management Plan: Summary Report

APPENDIX A

STUDY OF SOUTHERN HILLS LAKE TO DETERMINE THE POSSIBLE LOCATION OF WATER LEAKAGE

Study for
The City of Springfield, Missouri
Department of Public Works
under contract number
88-0062

by
Kenneth C. Thomson, Ph.D.
Consulting Geologist
Certified Professional Geologist No. 6552

November 7, 1988

INTRODUCTION

STATEMENT OF THE PROBLEM

The upper Southern Hills Lake is fed by a spring at its upper end. The flow is approximately 80 to 100 gallons per minute. This flow is enough that the level of the lake should be at the top of the spillway with water flowing over the spillway at Southern Hills Blvd. Normally, the water level is about 7 inches below the spillway and it stays at this level except during times of elevated rainfall, at which time the water fills up to overflow at the spillway. With no water going over the spillway, and the amount of inflow greater than the amount that could be accounted for by evaporation, the conclusion is that some of the water is leaking out of the lake. The problem is to find where that leak is and if possible where the water is going, its point of resurgence.

METHODS OF INVESTIGATION

Standard techniques of geologic mapping were used to determine the geology at the site. Careful inspection of all outcrops in the area was conducted several times during the summer and fall of 1988. Aerial photographs taken in 1968 were used to identify the photolineaments and other structures in the area. Sewer plans and plans for the spillway were also examined during the study. In addition, the elevation of the top of the spillway was determined through the use of a dumpy level measured from the bench mark at the spillway west side.

GEOLOGY OF THE SITE

The area around the north Southern Hills Lake is underlain by the Burlington Limestone, a medium bedded, light gray, crystalline crinoidal limestone. Outcrops of the Burlington can be seen on the west side of the lake near the dam. In the Springfield area, this rock is very susceptable to solution along bedding planes and fractures, thereby acting as the host for a great many caves and springs.

Residuum covers the Burlington throughout the area to a variable depth. This is the material that is the weathering product of the limestone and it consists of chert and soil covering the irregular bedrock surface.

The limestones have a general westward dip which can only be measured in feet per mile. No faults can be found locally, but a major photolineament has been found which cuts through the lake from the southwest to the northeast (figure 1 and 2). This fracture was originally mapped for a study conducted in 1980-81 and was varified for this study by examining the 1968 aerial photographs. No lineaments were found to cross the two lakes to

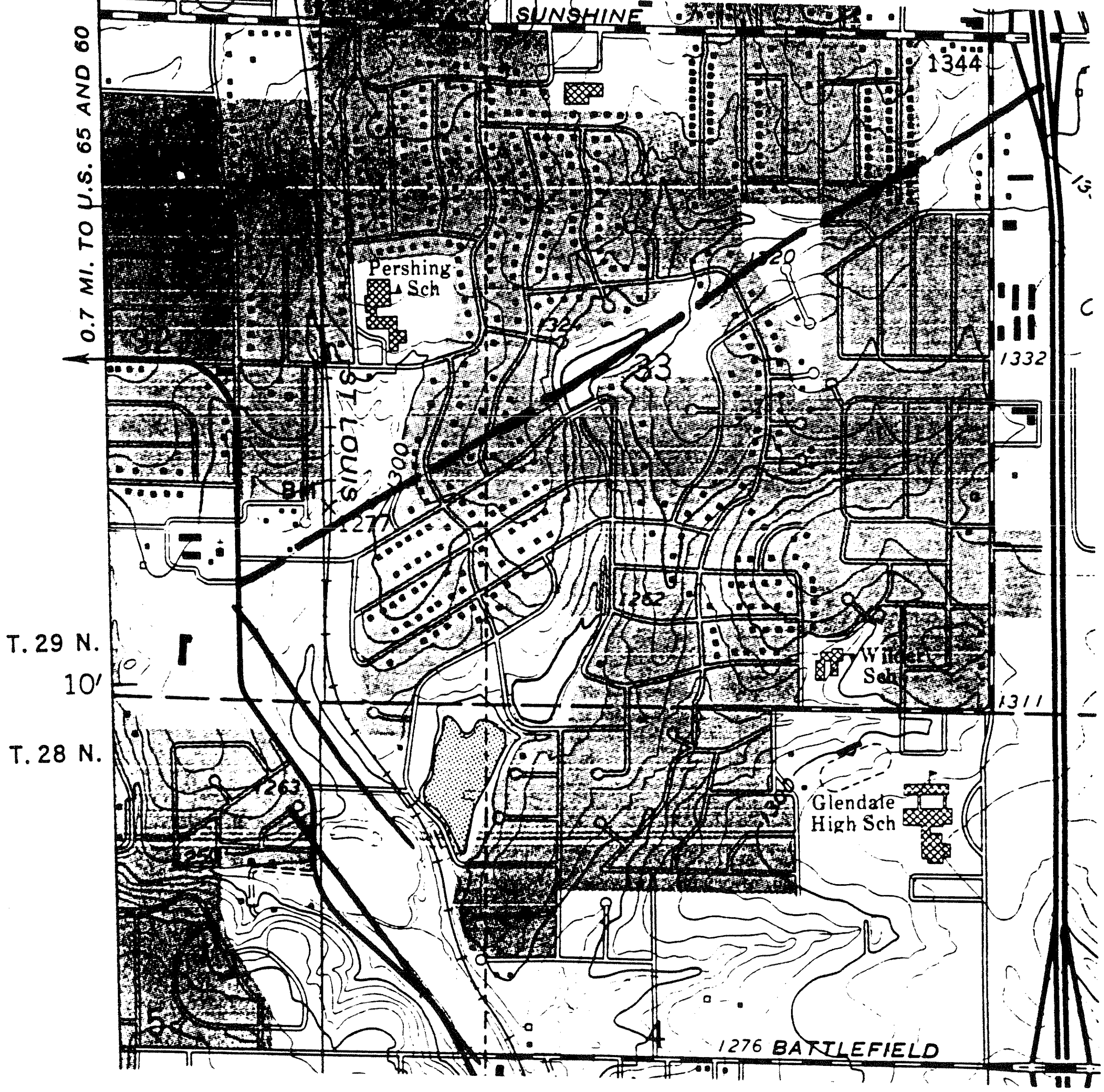


Figure 1. Enlarged portion of the Galloway Quadrangle topographic map showing the location of The Southern Hills Lake and the photo-lineament that passes through it.

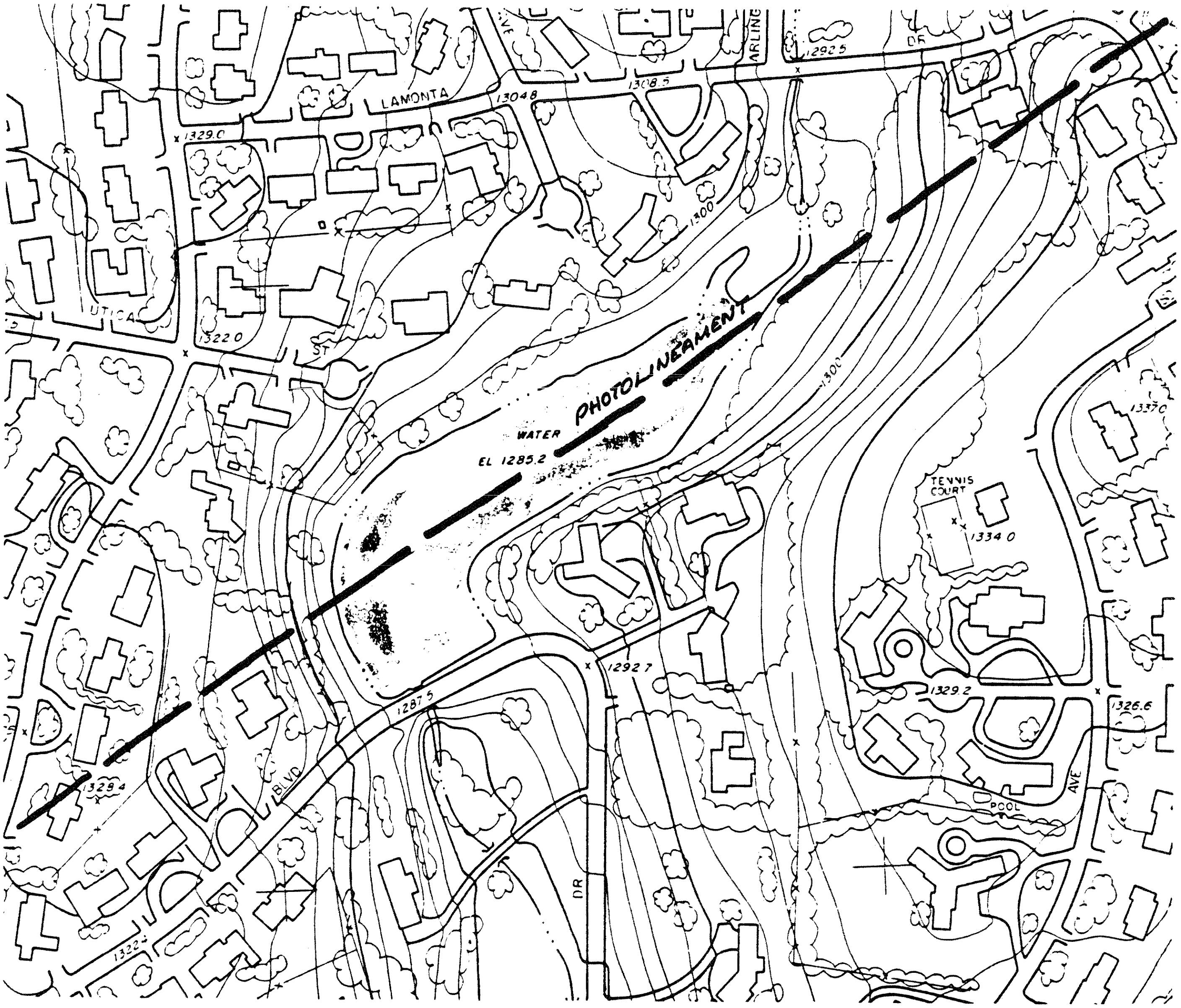


Figure 2. Reduced portion of the large scale topographic map of section 33, T.29 N., R.28 W., showing better detail. The photolineament is shown passing through the lake from the northeast to the southwest.

the south. The photolineaments are generally caused by fractures which weaken the rock allowing solution and erosion to differentially lower the ground surface creating the lineament.

HYDROLOGY

Each of the lakes in Southern Hills maintains its water level through spring flow. Since the study pertained to the upper lake, its spring was investigated and the flow estimated at 80 to 100 gallons of water per minute. This water probably is recharged from the area to the north and northwest of its opening. The springflow in each of the two lower lakes is sufficient to not only maintain the level of water in the lakes, but sufficient to provide flow over the spillway. The amount of water going over the spillway in these two lakes is about the same as the water flow from the spring in the upper lake. There is no flow over the spillway at the upper lake. This definitely indicates that there is loss of water from the lake. The question is where is the water going?

Dye tracing was conducted by Gene Thomas of the Public Works Department. Dye was placed in the upper lake in amounts great enough to turn the lake green. No dye showed up in either of the two lower lakes. Careful examination showed no evidence of water moving through the dam. Loss of water therefore probably does not go in that route.

The evidence of a photolineament going through the lake from southwest to northeast gives a likely place in which leakage takes place. Photolineaments are natural places for water to move through the rock. It is highly likely that the water migrates into the fractures that follow the photolineament and flows to the southwest, eventually flowing into the system that connects with Sequiota Cave and spring.

LAKE LEVELS

The lake level has fluctuated over the years. From the data obtained from sewer line plans and other data, the following levels have been documented:

1969 elevation............1283.71
1974 elevation............1284.38
USGS elevation............1285.20
1988 elevation............1283.60

It is not known whether the elevation was measured during a wet time or a dry time. The 1988 elevation was measured during a dry period and was very comparable to the 1969 elevation. It appears that the leakage has been occurring at least since 1969.

SHORELINE DAMAGE

One of the detrimental effects attributed to the leakage has been the damaged shoreline around the lake. This probably would not occur under normal circumstances because the normal status of the lake is the low water mode. With the lowered water, there should be a chance for vegetation to grow at the shoreline. This has not taken place. A probable reason for the damage is more likely attributed to the water fowl that are much more abundant in this lake than in the lower two. These birds continually find food at the shoreline and more likely can cause the damage that can be seen. Another detrimental effect of these birds is the high amount of fecal matter which has accumulated within the lake. In effect, the lake is a sewage lagoon for the birds.

CONCLUSIONS

After carefully examining the lakes and all the possible data available, the following conclusions were drawn:

1. The lake is leaking and losing somewhere near 80 - 100 gallons of water per minute.

2. The leakage is probably taking place through the fracture zone that created the photolineament through the lake from the south-west to the northeast.

3. No evidence was found of leakage through the dam.

4. Water from the lake probably could be traced to Sequiota Cave and spring. This has not been varified, but could probably be determined by water tracing techniques beyond the scope of this study. Most of the water in this part of the city can be traced to Sequiota Cave and Spring.

5. The lake is badly polluted with the feces of the waterfowl that inhabit the lake. This is also spread into the shallow groundwater migrating to Sequiota Cave and Spring.

6. The damage to the shoreline may in part be due to lowered shoreline, but is just as likely caused by the scavanging action of the waterfowl that inhabit the lake.

CERTIFICATION

I hereby certify that I have conducted the geologic work in this report and that I am a Certified Professional Geologist under the rules and regulations of the American Institute of Professional Geologists.

Kenneth C. Thomson

Kenneth C. Thomson, Ph.D.
CPG No. 6552

APPENDIX B

Southwest Missouri State
UNIVERSITY

November 23, 1999

Mr. Todd Wagner
Department of Public Works
City of Springfield
Springfield, Missouri 65804

Dear Todd,

I am enclosing a summary of algal identifications that I made from samples that you brought to me on November 18, 1999. These samples were from various locations in the Southern Hills Lakes. Algal taxa were identified to genus, and only those genera that were obvious (dominant) were recorded.

As in many algal communities some contain 1-5 dominant genera while there are 20-50 other genera that are present and recorded only after extensive examination.

One sample, Seep at L3, contained iron bacteria and I did not list it. At the same site another collection yielded *Chara*, according to some, not an alga. I am of the old school and consider it in the algal realm.

I did not have plankton samples to evaluate. I believe that this represents a flaw in the collection, as phytoplankton in this area during the summer contains *Microcystis*, species of which are known to produce algal toxins, detrimental to animals including humans. Also absent were more sites that contained *Vaucheria*, which I found to be very common in the summer, comprising the bulk of the algal mat at the N end of the uppermost lake.

It would be an additional piece of information if there were a map of the "three lakes" and on which the algal collection sites could be pinpointed.

Thanks for the opportunity of participating in this project.

Sincerely yours,

Russell G. Rhodes, Professor of Biology and Director, Center for Scientific Research and Education.

Department of Biology
901 South National Avenue Springfield, Missouri 65804-0095 (417) 836-5126 TDD: 1-800-735-2966 Fax: (417) 836-4204

#5

Algal Collections from Southern Hills Lakes, Springfield, Missouri
Time Frame of Collections, November 16, 17, 1999

Table 1. List of Dominant Algal Genera and Collection sites including Collection notes

List of Dominant Genera		L2- Spring	L2-Dam	L3-Spring-Nside	Below Spring-before L1	L3-South Side	L1-Spillway	L2-SE Side-Rocks	L2-S Side Floating	L2-Eside below spring	L1NSide Next to Storm Pipe	L3-Seep	L3-Rock-underwater	L1- Wbank-N o
				Collection Sites										
Chara	micro													
Cladophora			x					x	x	x	x		x	x
Closterium														
Cryptomonas					x		x		x		x	x		
Cymbella										x				x
Desmidium							x			x	x			
Eunotia				x										x
Fragillaria				x	x			x	x	x			x	
Frustulia														
Melosira		x			x		x			x	x			
Microspora														
Mougeotia			x					x	x				x	
Oedogonium			x								x			
Oscillatoria		x			x	x	x			x	x	x		
Pinnularia														
Pithophora								x						
Rhizoclonium				x										
Spirogyra	[illegible]	x	x			x	x	x	x	x	x	x		x
Synedra													x	x
Vaucheria	dominant							x						
Zygnema	[illegible]					x	x		x		x			x

th Side	L1-Spillway	L2-SE Side-Rocks	L2-S Side Floating	L2-Eside below spring	L1NSide Next to Storm Pipe	L3-Seep	L3-Rock-underwater	L1- Wbank-N of Dam	L3-Rock Underwater	S1-Floating	L3-Seep	L3-Seep	Scum next to L3-Seep
											x		
		x	x	x	x		x	x					
										x			x
	x		x		x	x							
				x				x					
	x			x	x								
								x					
		x	x	x			x						
													x
	x			x	x								
									x				
		x	x				x						
					x								
x	x			x	x	x							
													x
		x											
x	x	x	x	x	x	x		x	x	x			x
							x	x	x				
		x											
x	x		x		x			x	x	x			

Vegetational Survey of the Southern Hills Lakes,
Springfield, MO
July 21, 2000 to August 6, 2000

Submitted by: Dr. Larry Stauffer
Emeritus Professor of Botany
Drury College

Preface

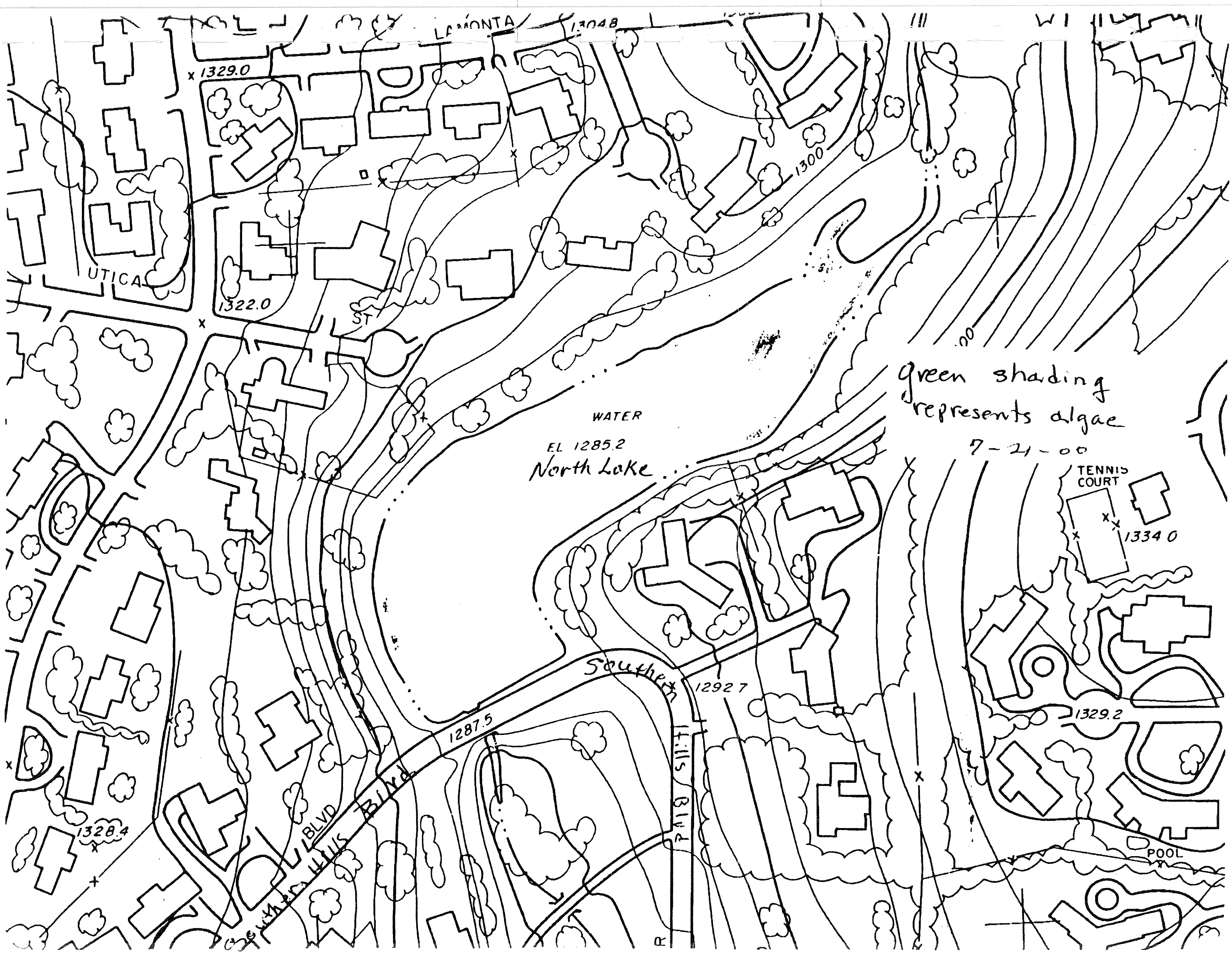
This paper is the final product of an abbreviated short-term analysis of the vegetation in and around (in close proximity to) the three Southern Hills Lakes. The results are presented in the following "two-part" report. Part I identifies (by common name when possible) the species of **non-vascular (algae) and vascular** aquatic plants. No provisions were made to include possible submerged plants. It is important to note that, less than a week prior to the beginning of this study, the run-off from a heavy rainfall may have "flushed" the lakes of a major portion of the floating vegetation-- this author had not see the lakes prior to this study.

PART 1: Aquatic Vegetation

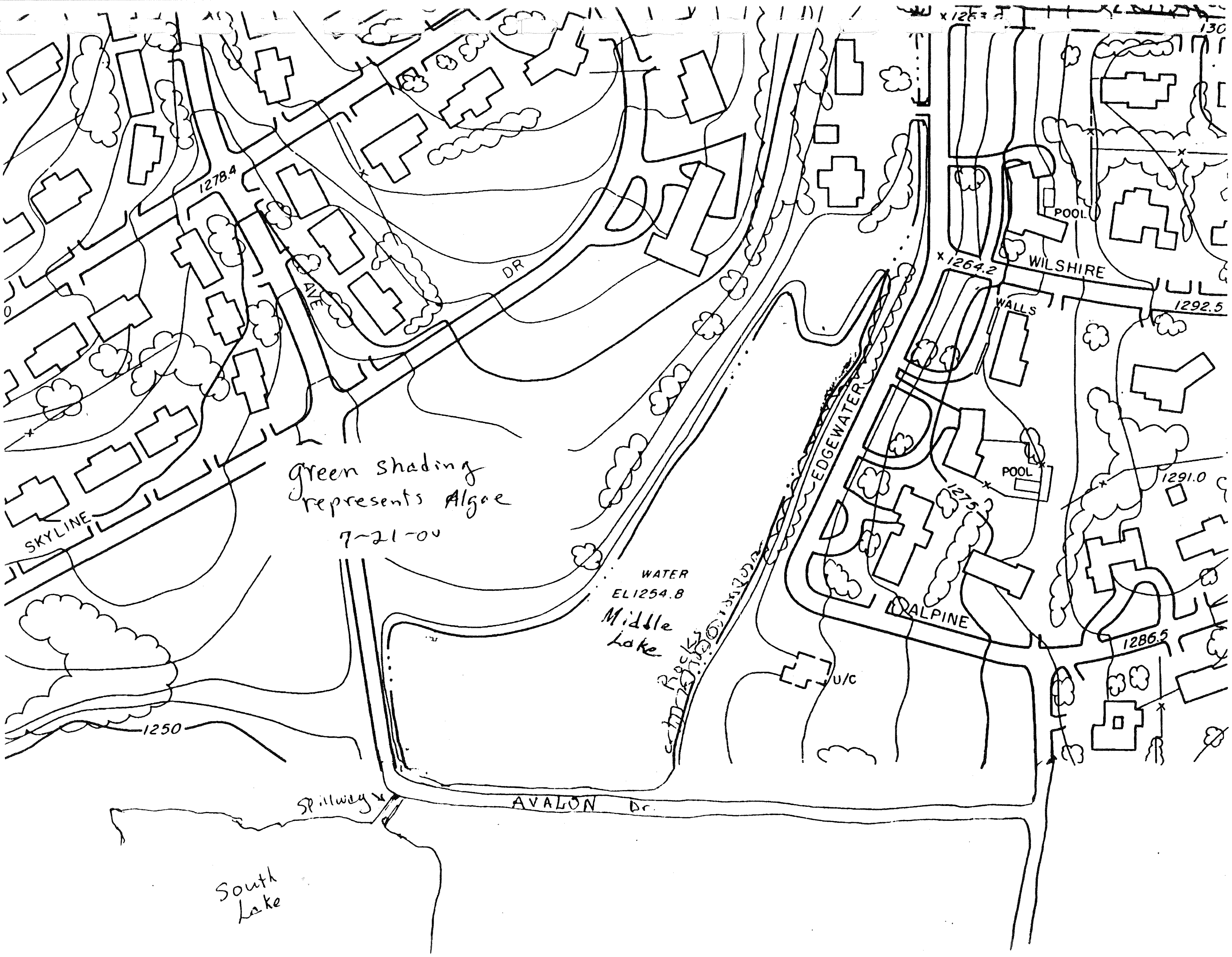
July 21, 2000: Morning rain shower, overcast skies. Water somewhat muddy/murky except for shallow areas along margin of lake. Samples of "floating masses" were collected from the shoreline using a garden rake and immediately transferred to glass containers filled with lake water from that area. Samples were taken from both north and south ends of the lake as well as east and west sides of mid-lake. By design no determination was made concerning any possible submerged plants in the deeper, muddy parts of the lake.

North Lake

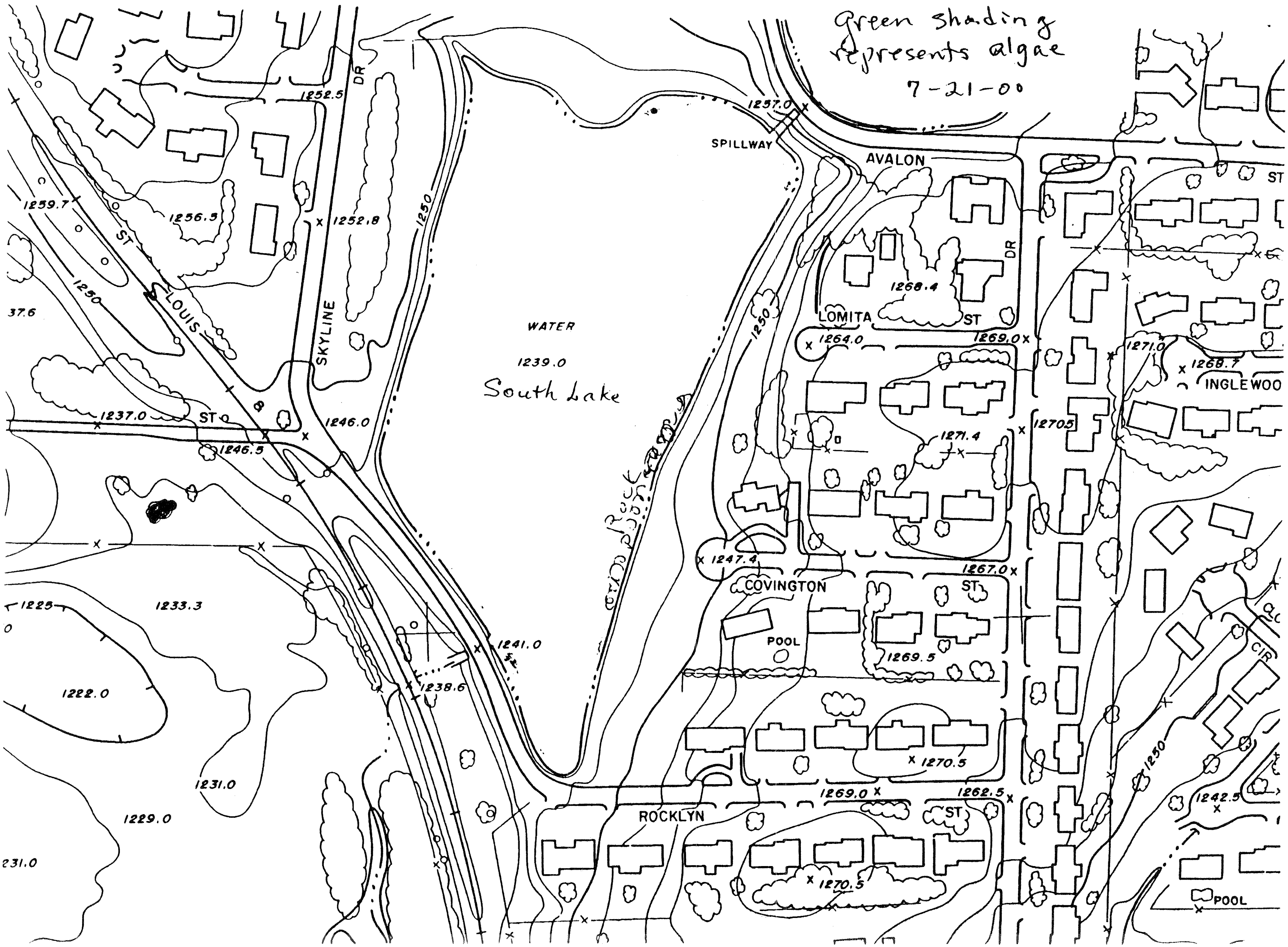
Floating masses were abundant in the north end of the lake forming a more or less continuous coverage around the entire margin of the lake approximately 1-2 feet from the shoreline. Relatively few clumps were scattered throughout the ~~lake surface~~.



LAMONTA
1304.8
1329.0
UTICA
1322.0
ST
1300
WATER
EL 1285.2
North Lake
green shading
represents algae
7-21-00
TENNIS
COURT
1334 0
1329.2
POOL
Southern
1292 7
Hills Blvd
1287.5
BLVD
1328.4



WILSHIRE
POOL
WALLS
1292.5
1264.2
1263.2
1278.4
DR
AVE
SKYLINE
EDGEWATER
POOL
1275
1291.0
ALPINE
1286.5
U/C
WATER
EL1254.8
Middle Lake
Rocky
Green shading represents Algae
7-21-00
1250
Spillway
AVALON Dr.
South Lake


Green shading represents algae
7-21-00
South Lake
WATER
1239.0
SPILLWAY
1257.0
AVALON
DR
LOMITA
ST
SKYLINE
LOUIS
ST
COVINGTON
ROCKLYN
INGLEWOO
CIR
POOL
POOL
Rock
1250
1250
1250
1250
1252.5
1252.8
1256.5
1259.7
1237.0
1246.5
1246.0
1241.0
1238.6
1247.4
1264.0
1268.4
1269.0
1271.4
12705
1271.0
1268.7
1267.0
1269.5
1270.5
1269.0
1262.5
1270.5
1242.5
1233.3
1225
1222.0
1231.0
1229.0
231.0
37.6

North Lake aquatic vegetation continued:

Non-vascular microscopic "plants"			vascular seed plants
Oscillatoria - - -	green alga.	trace	water primrose
Spirogyra - - -	green alga	trace	broad-leaf pond weed
Hydrodictyon- -	green alga	dominant FA	duckweed
Oedogonium - -	green alga	dominant FA	watergrass
Ulothrix - - - - -	green alga	abundant	burr-grass
Zygnema- - - -	green alga	abundant-dominant FA	
Diatoms - - - -	gold/brown	numerous	

Middle Lake

Floating masses less numerous. Some concentration in north and south ends of the lake. Minor accumulations along west side and "lower" east side. Major central area relatively clear of floating masses.

Oedogonium	green alga	dominant FA	watergrass
Spirogyra	green alga	trace FA	water primrose
Zygnema	green alga	trace FA	duckweed
Desmids	green alga	trace	
Diatoms	gold/brown	trace	

South Lake

Floating masses somewhat abundant at north end of lake on either side of the spillway from the middle lake. Masses extend approximately 2-3 feet from shoreline. Other accumulations at the south end of lake on either side of the spillway and a short distance "up" the east side. Central portion of lake essentially clear of floating masses.

Spirogyra	green alga	dominant FA	water primrose
Zygnema	green alga	trace FA	duckweed
Diatoms	gold/brown	trace	broad-leaf pondweed

PART II: Terrestrial vegetation at (and near) shoreline

The following lists the more "frequently observed" herbaceous seed plants at water's edge and within 3-5 feet of the shoreline. Most seed plants observed were without flowers, therefore identification was based solely on vegetative structures. The term "lawn weeds" refers to a variety of weed commonly found interspersed with grass in many lawns. Most common species include plantain, pigweed, chickweed, violet, dandelion, clover, vetch, lespedesa, crabgrass amd bindweed.

North-Lake:

East side from Southern Hills Blvd. north to inlet.

All along the east side of the lake property owner's lawns extent to the waters edge. The lawns near the lake are a mix of grasses (blue, Bermuda etc) and violet, plantain and other lawn "weeds" The lawns are mowed and well-kept. Considerable evidence of water fowl present-especially along west side of the lake.

trees/shrubs	herbaceous plants
	sedges
	wild strawberry
	plantain
	smartweed
black walnut	
	violet
wild rose	
	foxtail
mulberry (sprouts)	ragweed
elm "	
willow "	
	horse nettle
	Euphorbia spp.
	mint
	bindweed
	jewel weed
weeping willow	sedge spp.
honey locust	
ash	

North Lake terrestrial vegetation continued:

trees/shrubs	herbaceous plants
	plantain
walnut	violet
wild rose	foxtail
mulberry	jewel weed
	vetch
	lespedeza
	sedge
	Johnson grass
	milkweed
	jewel weed
	ragweed
	dock
	oxalis
	violet
	wild strawberry
weeping willow	
ash	
honey locust	

South end parallel to Southern Hills Blvd. and north to inlet:

Property owner's lawns extend to the water's edge. All are closely mowed and well kept. Heavy waterfowl use evident. Lawn grasses are primarily bluegrass and Bermuda. Lake's edge, like most others, is a mix of the following, nothing especially dominant.

	ragweed
	mixed grasses
	horse nettle
	Euphorbia (spurge)
	mint spp.
	bindweed
	smartweed
	vetch
wild cherry	
	lawn grass mix with common lawn weeds (plantain, dandelion, clover etc.)
black walnut	
ash	
mulberry	
silver maple	
honey locust	

ash
willow

West side: Beginning at Southern Hills Blvd. then north to inlet.

Property owner's lawns extend to the edge of the lake. Lawns are closely mowed and are a mix of lawn grasses and common lawn weeds, similar to all other lawn areas around the Southern Hills Lakes. Evidence of heavy waterfowl use is obvious.

trees/shrubs	herbaceous plants
	smartweed
	vetch
wild cherry	
	lawn grass/weed mix
willow	
	water primrose
	smartweed/watergrass mix
black walnut	
ash	
mulberry	
silver maple	
honey locust	
ash	
willow	

Middle Lake

Lake surface mostly clear except for north end inlet and peripheral areas which are more-or-less covered with "patchy" clumps of floating algae.

Terrestrial plants are listed in order as indicated below. At points where private properties extend to lake, if no other vegetation present, a mixture of cultivated lawn grasses (bluegrass, Bermuda etc.) and common lawn weeds (plantain, pigweed, violet, etc.) persists.

trees/shrubs	herbaceous plants
	lawn grasses
	bindweed
	clover
dogwood	
willow	
dogwood	
elm	
	pigweed
	vinca
	milkweed
	plantain
	horse nettle
elm	
dogwood	
ornamental plantings	
Osage orange	
sycamore	
tree of heaven	
hackberry	
elm	
elm	
Ailanthus	
elm	
silver maple	
black cherry	
black walnut	
	milkweed
	foxtail
	clover (abundant)
elm	
	ragweed
	Johnson grass

elm
silver maple
Chinese elm
silver maple
    horse nettle
    poison ivy
elm
wild grape
wild rose
elm
willow/sycamore/elm sprouts
    algae/duckweed mix
honey suckle
    bindweed
    wild strawberry
    plantain/clover mix
oak (Chinquapin)

Juniper (red cedar)

East side----from south-east corner of lake north to inlet.
Two residences have lined property along lake with rock. Lawn grass (Bermuda) with some common lawn weeds (plantain etc.) extends the full width of the two properties.

trees/shrubs	herbaceous plants
	jewel weed
Bradford pear (cultivated)	pigweed
golden rain tree "	
Bermuda grass	
redbud	
dogwood	
cypress	
black walnut	
hackberry	
honey locust	
elm	
hackberry	
linden	lawn grass/plantain mix
black walnut	
hackberry	
sycamore	
elm	

Middle Lake terrestrial vegetation continued:

trees/shrubs	herbaceous plants
hackberry	
oak with Evonymus climbing trunk of tree.	
	vetch
wild cherry	
	lawn grass
	water primrose
	smartweed/water grass mix
black walnut	
ash	
mulberry	
silver maple/vine covered	
honey locust	

South Lake

West Side: Beginning at the spillway off Avalon Street and following shoreline around west side of lake to the southern most point. Property owners lawns extend to lake's edge. Lawns are closely cut and well kept. Some stone edging near southern end. Lake is relatively clean--some rooted water plants and duckweed in north end and floating clumps of algae around the periphery of the lake. Little evidence of waterfowl.

trees/shrubs	herbaceous plants
willow	
honeysuckle	
	water grass
	arrowhead
ash	
	lawn grass/weed mix
ash	
ash	
ash	
juniper (red cedar)	
	bush clover
willow	
poison ivy	
sycamore	
Evonymus	
	jewel weed
	arrowhead
hackberry	
	bindweed
	vetch
honeysuckle	
wild grape	
Evonymus	
	yellow composite
	duck weed
	bindweed
	mint spp.
	arrowhead
mulberry	
	ragweed
elm	
	bush clover
juniper (red cedar)	

black eyed susan
milkweed

South Lake terrestrial vegetation continued:

trees/shrubs	herbaceous plants
	Johnson grass
	white sweet clover
	Euphorbia (spurge)
sycamore	
sycamore	
sycamore	
sycamore	
	giant ragweed
	yellow composite
	broad-leaf floating plant
	horse nettle
	arrowhead
	lawn grass/plantain mix
	water primrose
willow	
	lawn grass/plantain (dominant)
	arrowhead

East side: **From southern-most point north to spillway at north end.** Rock line the lake's edge for approximately one-half the length of the lake. Lawn grass/weed mix backs up to rocks. Considerable waterweed along rocks and area near the spillway.

trees/shrubs	herbaceous plants
	black-eyed susan
	milkweed
	Johnson grass
	white sweet clover
	Euphorbia (spurge)
sycamores	
	giant ragweed
	yellow composite
	horse nettle
	arrowhead
	lawn grass/plantain mix
	water primrose

APPENDIX C

WWE

MEMORANDUM

To: Mike Giles, P.E.
Todd Wagner, P.E.
City of Springfield Public Works
Via E-mail: giles@ci.springfield.mo.us and wagner@ci.springfield.mo.us

Fred Palmerton, P.E., Chairman, Southern Hills Lakes Advisory Committee
Palmerton & Parrish, Inc.
Via E-mail: fred.Palmerton@ppimo.com

Steve Jones, Ph.D., Member, Southern Hills Lakes Advisory Committee
Drury University
Via E-mail: sjones@drury.edu

Robert Smith, for distribution to Southern Hills Neighborhood Association
Via E-mail: smithb@pcis.net

From: Wright Water Engineers, Inc.
David B. Mehan, P.W.S., Jonathan E. Jones, P.E. and Wayne F. Lorenz, P.E.

Date: March 20, 2000

Re: Supplement to Initial Monitoring Program for
Southern Hills Lakes and Sequiota Lake

BACKGROUND

After review of the information and data on the Southern Hills Lakes and Sequiota Lake that has been provided to us, we recommend that the initial monitoring program in our memorandum of November 2, 1999 be modified as described in this memorandum. This is necessary to address the specific characteristics of the lakes, which include the predominance of filamentous algae, large amount of sediment, high inflows, and occasional high bacteria levels. The monitoring program has also been modified to include data for further evaluation of control options. This program incorporates comments received on previous drafts from representatives of the City and Dr. Steve Jones. The monitoring plan described herein may require periodic adjustments in the future.

As requested, we have included Sequiota Lake in this plan. While we have not visited this lake, based on discussions with a number of you and review of existing information, it is our understanding that Sequiota Lake receives a large amount of nutrients from the springs that feed the lake, and that some of the problems with the lake are similar to those at Southern Hills. It is also our understanding that this lake was dredged several years ago. Therefore, at this time, we recommend that the same sampling be conducted at Lake Sequiota as with the Southern Hills lakes. We will notify you of any modifications to the sampling at Lake Sequiota after we visit the lake in early April.

OVERVIEW

We recommend that the scope of the data collection at each lake include: 1) continued sampling of inflows and lake water quality, 2) continued sampling of the springs that enter the lakes, 3) one-time lake bottom sediment sampling, 4) surveys of the types of weeds and algae, 5) inventory of shoreline conditions around the lakes, and 6) additional surveying and identification of wastewater (septic tank and sanitary wastewater) sources, to be conducted by City staff, building upon studies of this kind that the City has already conducted.[1] Existing data and data from the monitoring program will be used to address the following representative questions (this list is by no means exhaustive):

- What is the quality of inflows to the lakes?
- How important is the water quality of the springs?
- How important is wastewater from septic systems and sanitary sewer surcharges and leaks?
- How might wastewater sources be controlled?
- What algae control methods appear especially promising, based on the algae types present?
- What are the approximate magnitudes of water, sediments and pollutants entering the lakes?
- What is the quality of the sediment?
- What are the types of weeds and algae that need to be controlled?
- What other problems need to be managed?
- Are there opportunities to manage waterfowl use by modifying the shorelines?

Consistent with the field monitoring conducted to date, we envision that the monitoring will be carried out by City staff with assistance from Dr. Jones and his students. As discussed on March 13, 2000, it may be best to have City staff perform the water quality sampling and have Dr. Jones do the biological monitoring. WWE's role is to provide recommendations on what data need to be collected, data interpretation, and periodic recommendations for refinements to the program.

[1] City Wastewater Dept. staff have gathered extensive sanitary sewer leakage and surcharge data for the watershed tributary to Southern Hills Lakes, video, video camera, smoke tests, baseflow studies, mapping analysis, etc. These data are now being analyzed and any additional monitoring will be based upon the data gathered to date.

The following describes the components of the modified program. The proposed program is summarized in Table 1.

WATER QUALITY SAMPLING

Water quality samples should be collected from the surface inflows, springs, and lakes. Both storm and dry weather samples should be collected from the inflows. The goal should be to obtain at least two samples of each this spring and summer (Table 1).

We recommend the following for the water quality monitoring:

- Sampling locations: See Figure 1
- Sampling dates: April through August or September 2000
- Type of samples: grab for springs and inflow, composite for lake and sediment samples
- Parameters to analyze: See Table 2

The flow rates into the lake should be measured or estimated when a sample is taken at an inflow point or spring. This can be done with a current meter, using hydraulic calculations at a control section such as the bridge at La Motta, or as a coarse visual estimate (see November 2, 1999 memorandum). Suggested data forms are attached.

The parameters that should be measured for each sample are shown in Table 2. This table indicates whether the parameter is to be measured in the field or by the laboratory, and includes recommended minimum detection limits (MDL). We recommend that the same parameters be measured in each sample, except that chlorophyll a should be measured in lake samples. Also, the lake "profiles" entail measuring water temperature and dissolved oxygen from the lake surface to bottom using a probe.

Spring and inflow samples can be grab samples from the center of the flow. In-lake samples should be composite samples taken from the upper 2 feet of each lake at 3 to 4 locations in each lake. Likewise, the sediment samples should be composite samples of the upper 12 inches of sediment from 3 to 4 locations around at the lake inlets.

As discussed in our November 1999 memorandum, consistent sampling protocols should be used for all sampling. It is particularly important that sample hold times are adhered to for the bacteria samples.

If feasible, we encourage City staff to continue to collect runoff samples from the Sunshine/Highway 65 interchange for both total settleable solids (Imhoff Co~~v~~ne) and total suspended solids (TSS).

SEDIMENT SAMPLING

One composite sediment sample should be collected from each lake from 3 to 4 grab samples of sediment (12 inch depth) taken near the lake's inlet. The samples should be analyzed according to state protocols for hazardous disposal analysis. Total nitrogen and total phosphorus should be analyzed, along with any other parameters required by the state. We can refine the list of parameters to be measured in sediment once you obtain the state's requirements.

WEED AND ALGAE SURVEY

Surveys should be conducted at least monthly during the growing season to inventory the specific types of weeds and algae in each lake. Ultimately, the frequency of algae assessment will be best determined by field observations by Dr. Jones and his students, focusing on noteworthy changes in the algae composition. Video and photographs, which Bob Smith is planning on taking, will be useful for this purpose. These field surveys should address macrophytic and filamentous algae, aquatic macrophytes and emergent wetland vegetation. We do not recommend sampling phytoplankton at this time due to the work involved. A sketch should be made and photographs taken to show the distribution of algae and weeds in each lake. Samples should be taken, as necessary, to identify the species present. If possible, each survey should be completed at the time of water quality sampling to enable comparison of the data.

As per discussions with you, we do not recommend taking macroinvertebrate samples at this time. We suggest considering performing fish collections, depending on cost and preliminary results of the monitoring. If more information is needed on fish communities in the lakes, sampling can be conducted later in the summer.

IDENTIFICATION OF SHORELINE CONDITIONS

Existing information indicates that the lakes are used by a large number of waterfowl, which may be contributing a significant amount of nutrients to the lakes from their wastes. It may be possible to modify the shoreline configuration of the lakes to discourage waterfowl use and thereby decrease nutrient inputs. For example, planting of relatively dense shoreline vegetation discourages geese usage since they prefer long sight distances. Portions of lakes with grass to the water's edge are also experiencing shoreline erosion.

It is recommended that the condition of the shoreline of each lake be documented. This can take the form of photographs/video and a drawing showing the types of vegetation and any shoreline treatments (e.g., riprap) and improvements present. This survey can be completed when the weed/algae surveys are conducted.

CONTINUED ASSESSMENT OF POTENTIAL WASTEWATER SOURCES TO THE LAKES

Water quality data show periodic high levels of bacteria, nutrients, and biochemical oxygen demand (BOD) that resulted from accidental wastewater discharges from sanitary sewers. Available information also indicates that these are septic tanks and leach fields on the residential areas close to the Southern Hills Lakes and Sequiota Lake. While we understand that the City has comprehensively monitored the sanitary sewer system in the Southern Hills area, we suggest that the City continue to monitor the situation this summer. City staff are well versed in the techniques that can be used to establish wastewater sources, so we have not provided these herein. However, we note that it will be extremely important to interface this evaluation with Dr. Ken Thomson's projection of the boundaries of the recharge areas for the Southern Hills Lakes and Sequiota Lake.

Attachments

.C:\991-168\000ard\MemoMGilesetal2-28-00.doc

Table 1
Summary of Lake Monitoring Program
(See Table 2 for Parameters)

Sample Type[1]	Type of Sample[2]	Minimum Number of Samples[3]			
		Southern Hills Lakes			
		Upper	Middle	Lower	Lake Sequiota
Inflow					
• Storm	G	2	2	2	2
• Baseflow	G	2	2	2	2
Springs	G	2	2	2	2
In-Lake					
• Water quality	C	2	2	2	2
• Profile[4]	N/A	2	2	2	2
Sediment	C	1	1	1	1
Weed/Algae survey	V	2	2	2	2
Shoreline condition inventory[5]	V	2	2	2	2

1 See Figure 1 for locations.
2 G=grab sample; C=composite sample; V=visual estimate or description.
3 Samples should be collected at least one month apart, if possible. Collection of more than minimum number of samples is encouraged.
4 Profiles are necessary to determine whether lakes stratify and, if so, impact of stratification on temperature, pH, and dissolved oxygen on a function of depth.
5 Conducted at same time as weed/algae inventory.

TABLE 2

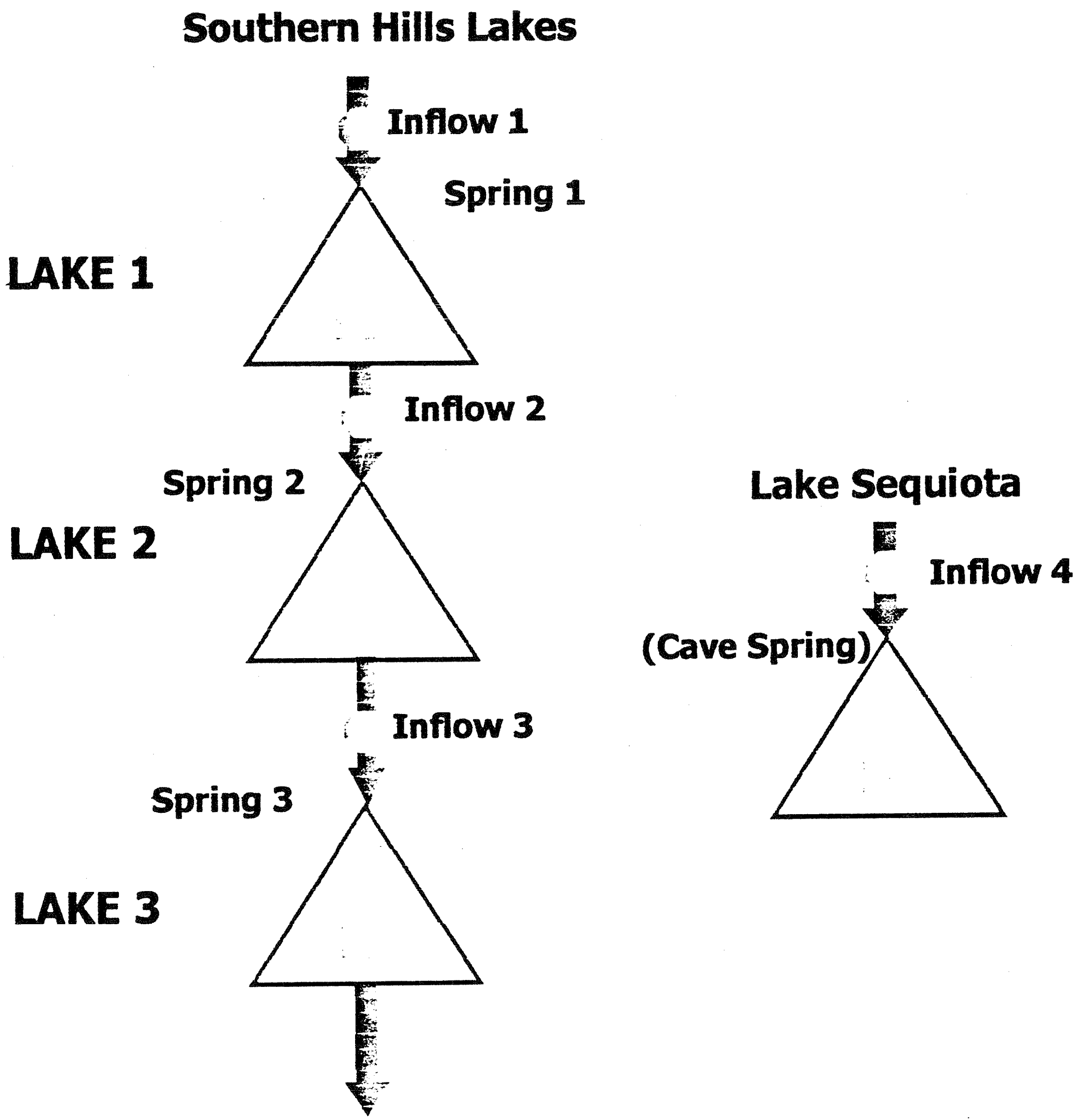
Parameters to be Measured for Water Quality Samples

Parameter	Recommended MDL[1]
pH (field)	0.2 s.u.
Hardness	5 mg/l
Total suspended solids (TSS)	5 mg/l
Fecal coliform and fecal streptococcus bacteria	1 colony /100 ml
Turbidity (field)	0.2 NTU
Total phosphorus	0.005 mg/l
Orthophosphate	0.005 mg/l
Total nitrogen	0.005 mg/l
Total kjeldahl nitrogen	0.005 mg/l
Nitrate-N	0.005 mg/l
Dissolved oxygen (field)[2] (depth profile)	0.2 mg/l
BOD_5	10 mg/l
Chlorophyll a [2]	0.005 mg/l
Water temperature (depth profile)[2]	0.1 C

C:\991-168\000ard\TABLE 2.doc

[1] MDL = minimum detection limit.
[2] In lake samples only.

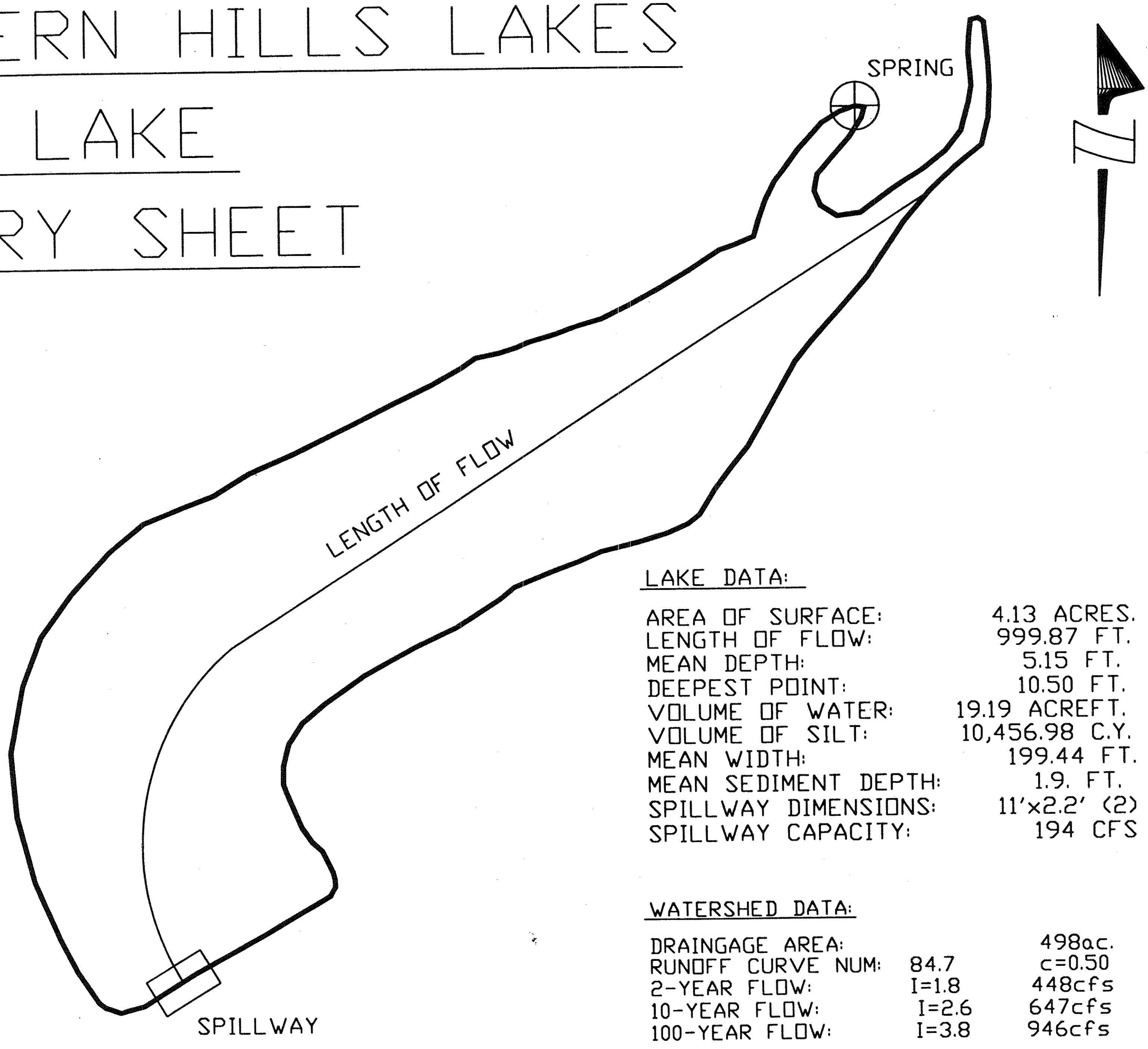
Figure 1
Southern Hills Lakes and Lake Sequiota Monitoring Program
Sampling Station Schematic



G:\991-168\000pap\Sampling Schematic.ppt

APPENDIX D

SOUTHERN HILLS LAKES
UPPER LAKE
SUMMARY SHEET



LAKE DATA:

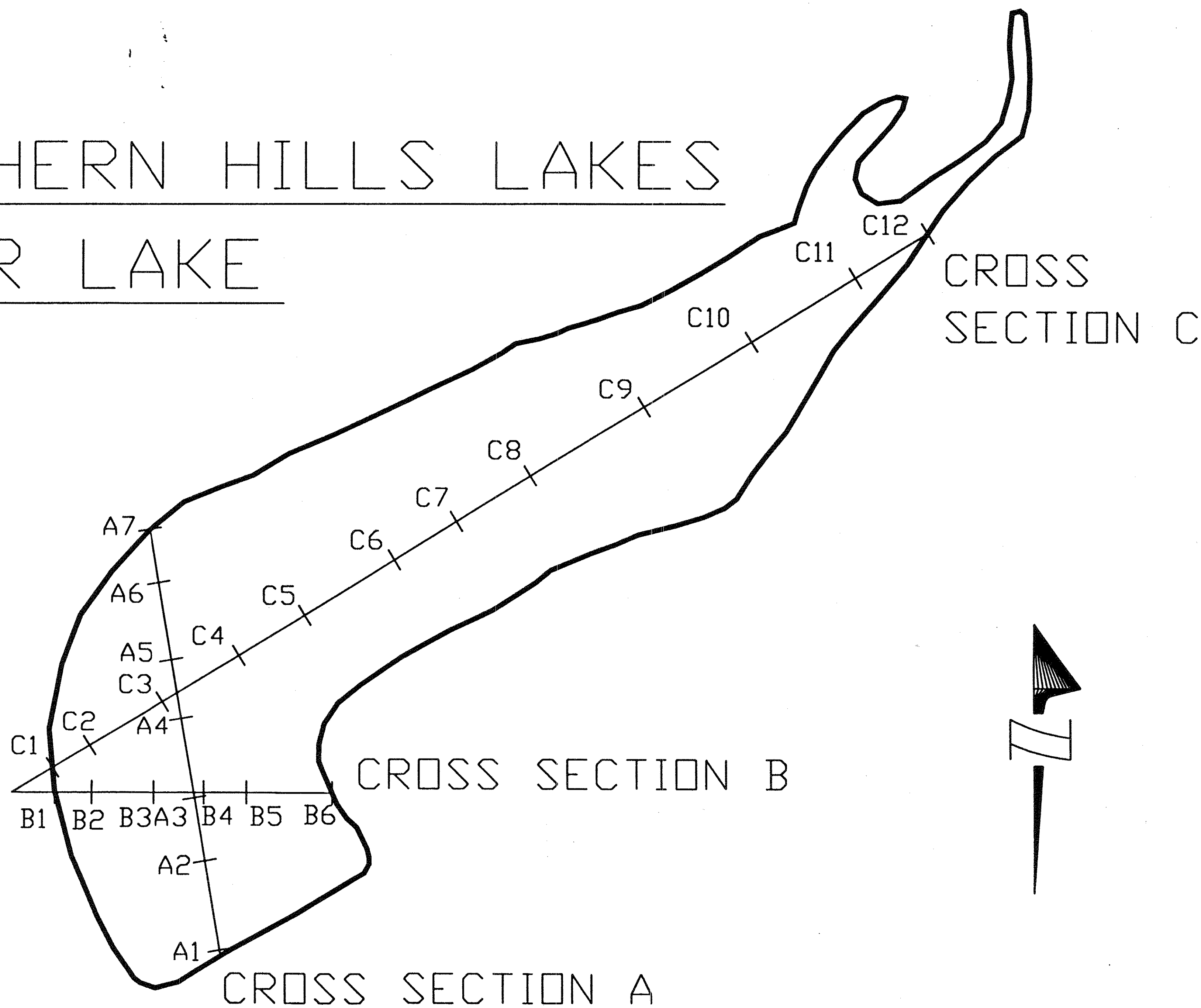
AREA OF SURFACE:	4.13 ACRES.
LENGTH OF FLOW:	999.87 FT.
MEAN DEPTH:	5.15 FT.
DEEPEST POINT:	10.50 FT.
VOLUME OF WATER:	19.19 ACREFT.
VOLUME OF SILT:	10,456.98 C.Y.
MEAN WIDTH:	199.44 FT.
MEAN SEDIMENT DEPTH:	1.9. FT.
SPILLWAY DIMENSIONS:	11'x2.2' (2)
SPILLWAY CAPACITY:	194 CFS

WATERSHED DATA:

DRAINGAGE AREA:		498ac.
RUNOFF CURVE NUM:	84.7	c=0.50
2-YEAR FLOW:	I=1.8	448cfs
10-YEAR FLOW:	I=2.6	647cfs
100-YEAR FLOW:	I=3.8	946cfs

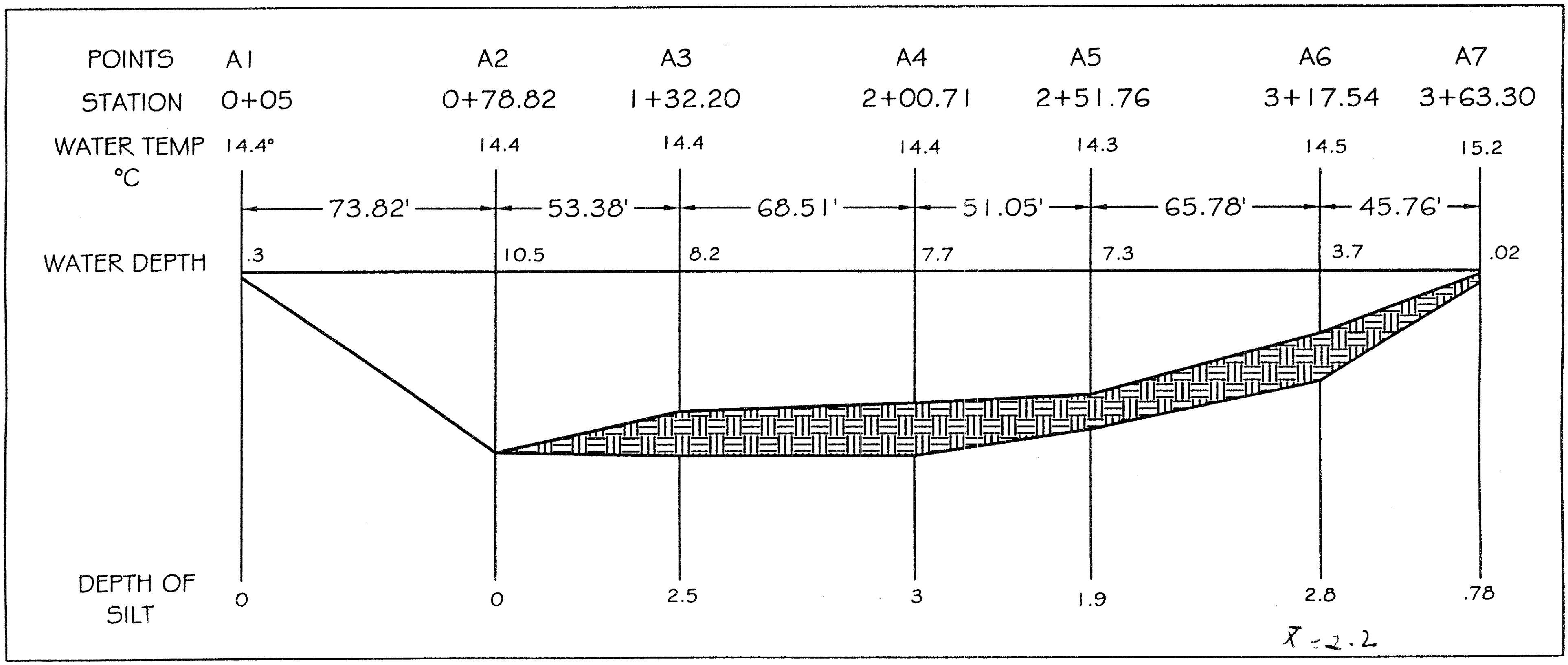
SOUTHERN HILLS LAKES

UPPER LAKE



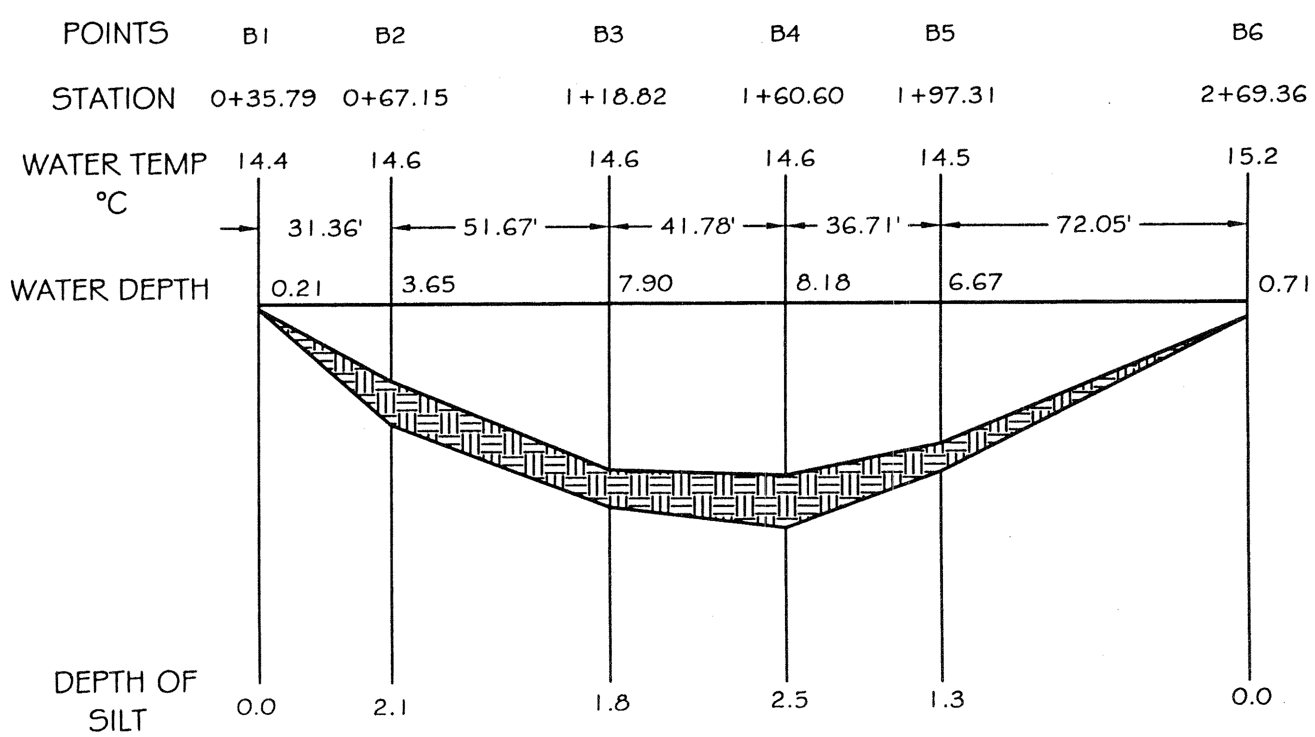
SOUTHERN HILLS, UPPER LAKE

CROSSECTION A



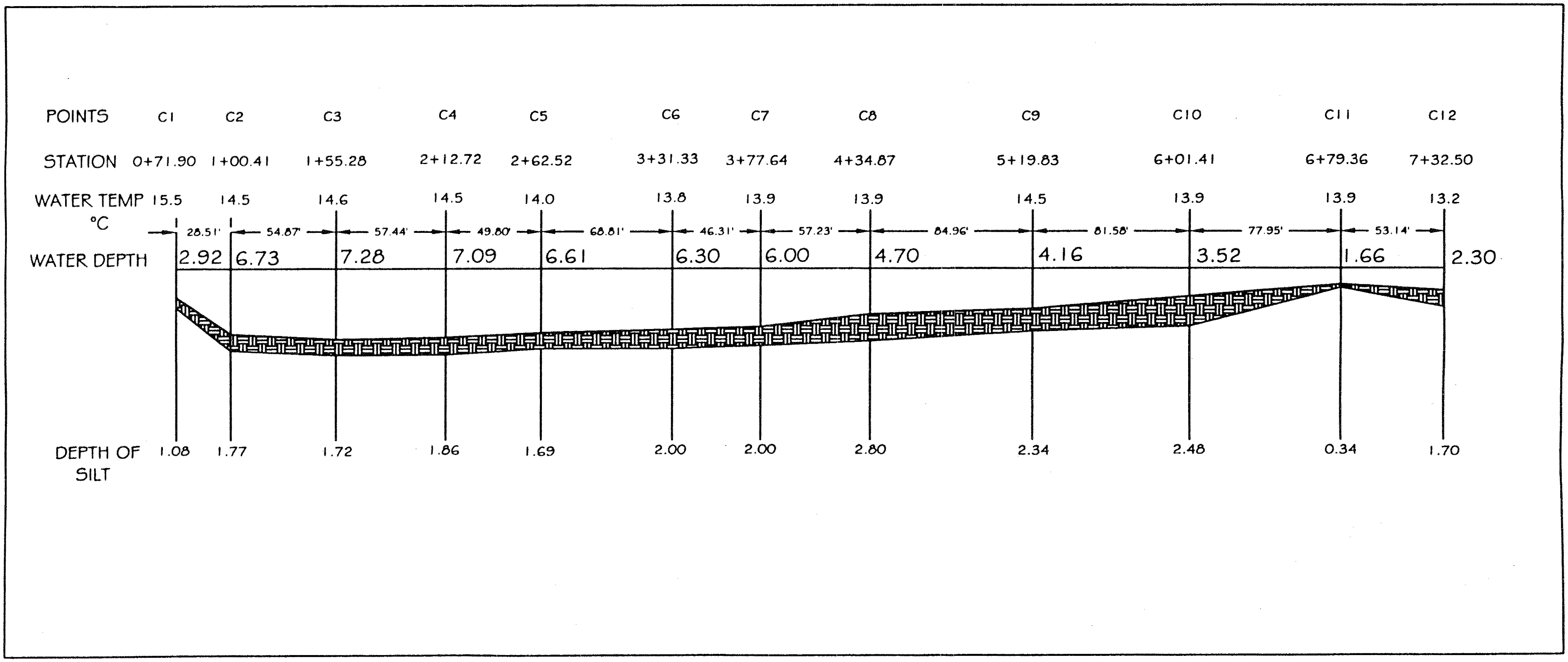
SOUTHERN HILLS, UPPER LAKE

CROSSECTION B



SOUTHERN HILLS, UPPER LAKE

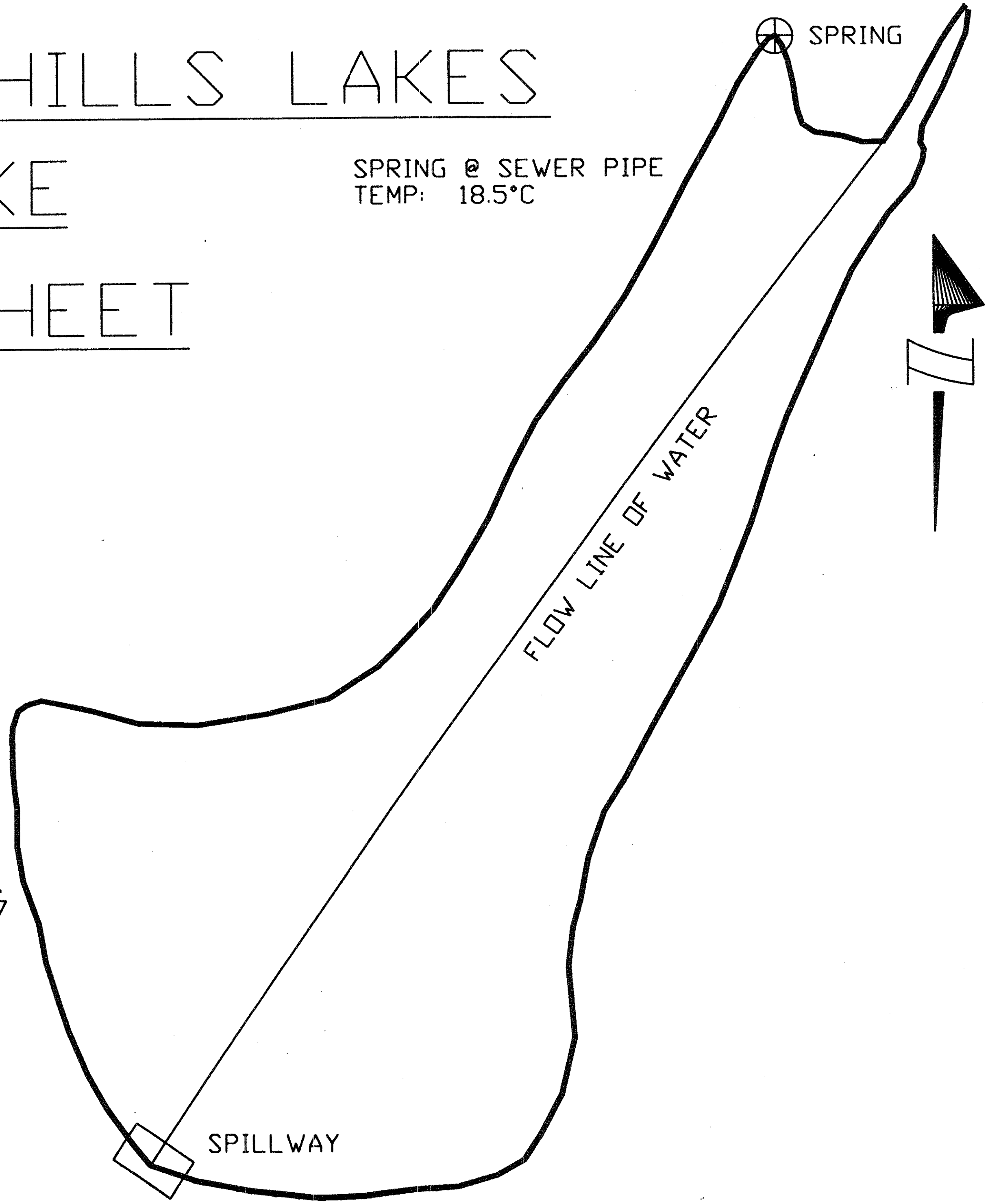
CROSSECTION C



SOUTHERN HILLS LAKES

MIDDLE LAKE

SUMMARY SHEET



LAKE DATA:

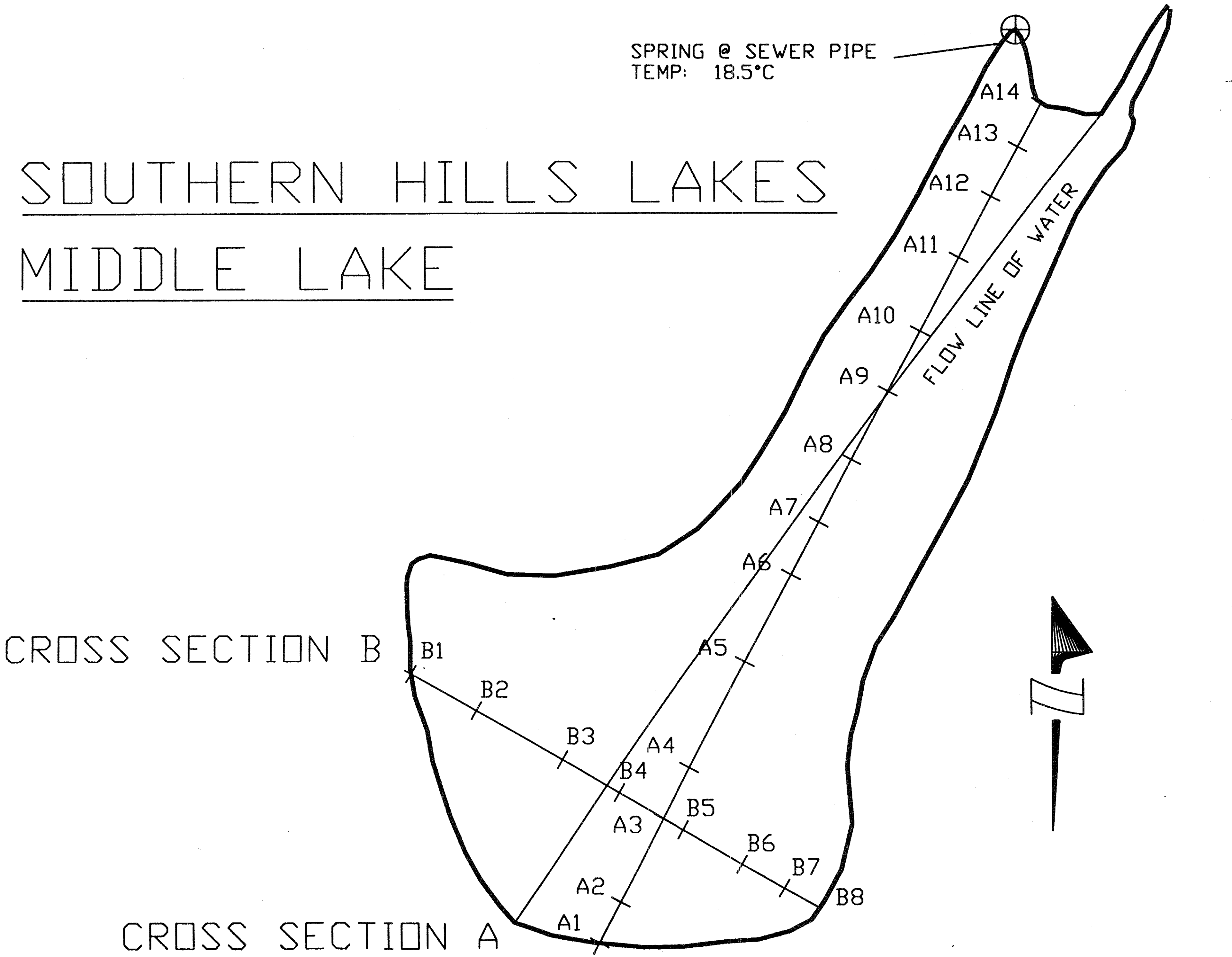
AREA OF SURFACE:	5.39 ACRES
LENGTH OF FLOW:	963.58 FT.
MEAN DEPTH:	5.79 FT.
DEEPEST POINT:	10.65 FT.
VOLUME OF WATER:	36.51 ACREFT.
VOLUME OF SILT:	13,901.23 C.Y.
MEAN WIDTH:	224.51 FT.
MEAN SEDIMENT DEPTH:	1.28 FT.
SPILLWAY DIMENSIONS:	5'x2.2' (2)
SPILLWAY CAPACITY:	88cfs

WATERSHED DATA:

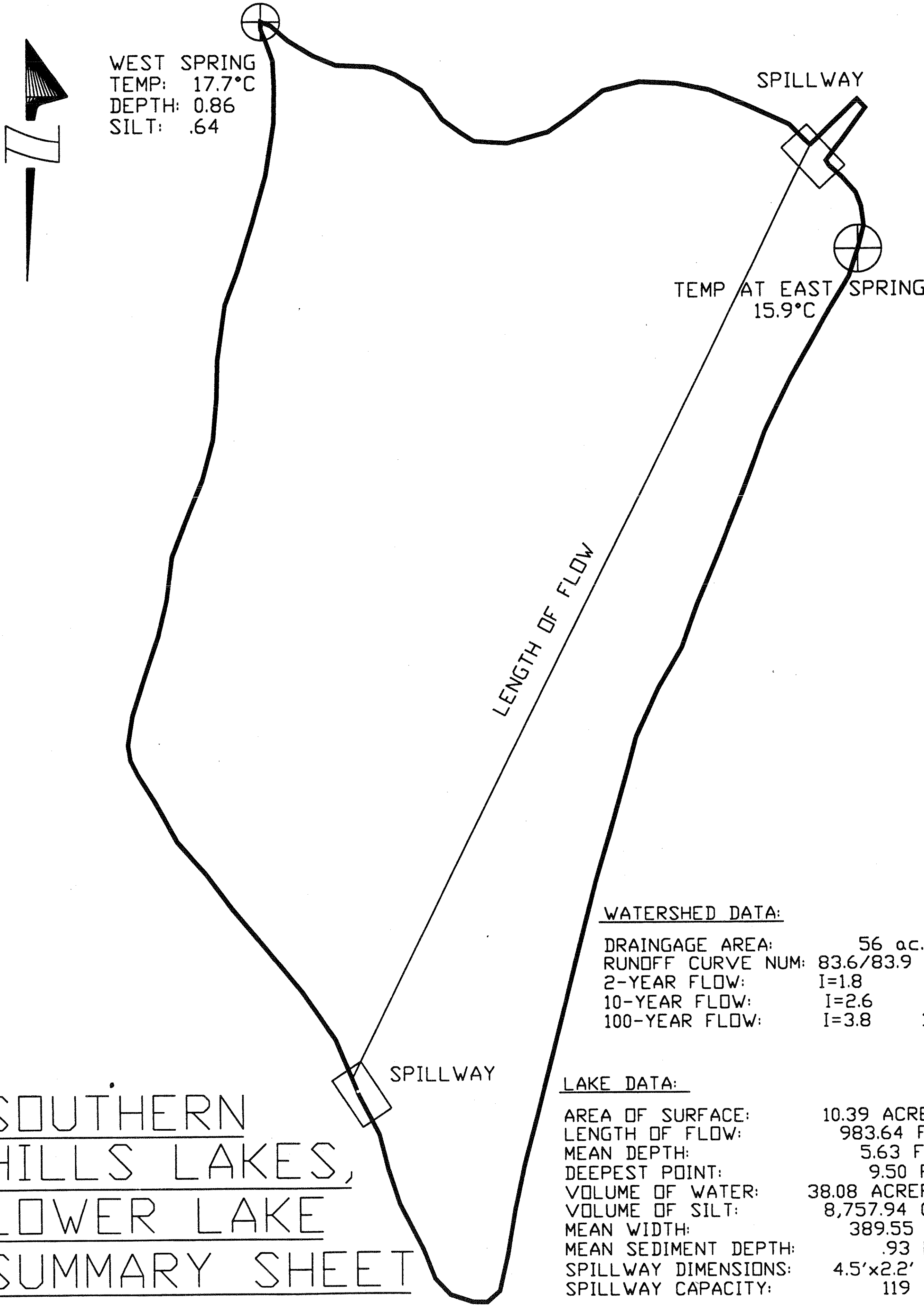
DRAINGAGE AREA:		90ac./588ac.
RUNOFF CURVE NUM.:	79.5/83.9	C+0.47
2-YEAR FLOW:	I=1.8	497cfs
10-YEAR FLOW:	I=2.6	719cfs
100-YEAR FLOW:	I=3.8	1050cfs

SOUTHERN HILLS LAKES

MIDDLE LAKE



SOUTHERN HILLS LAKES, LOWER LAKE SUMMARY SHEET



WATERSHED DATA:

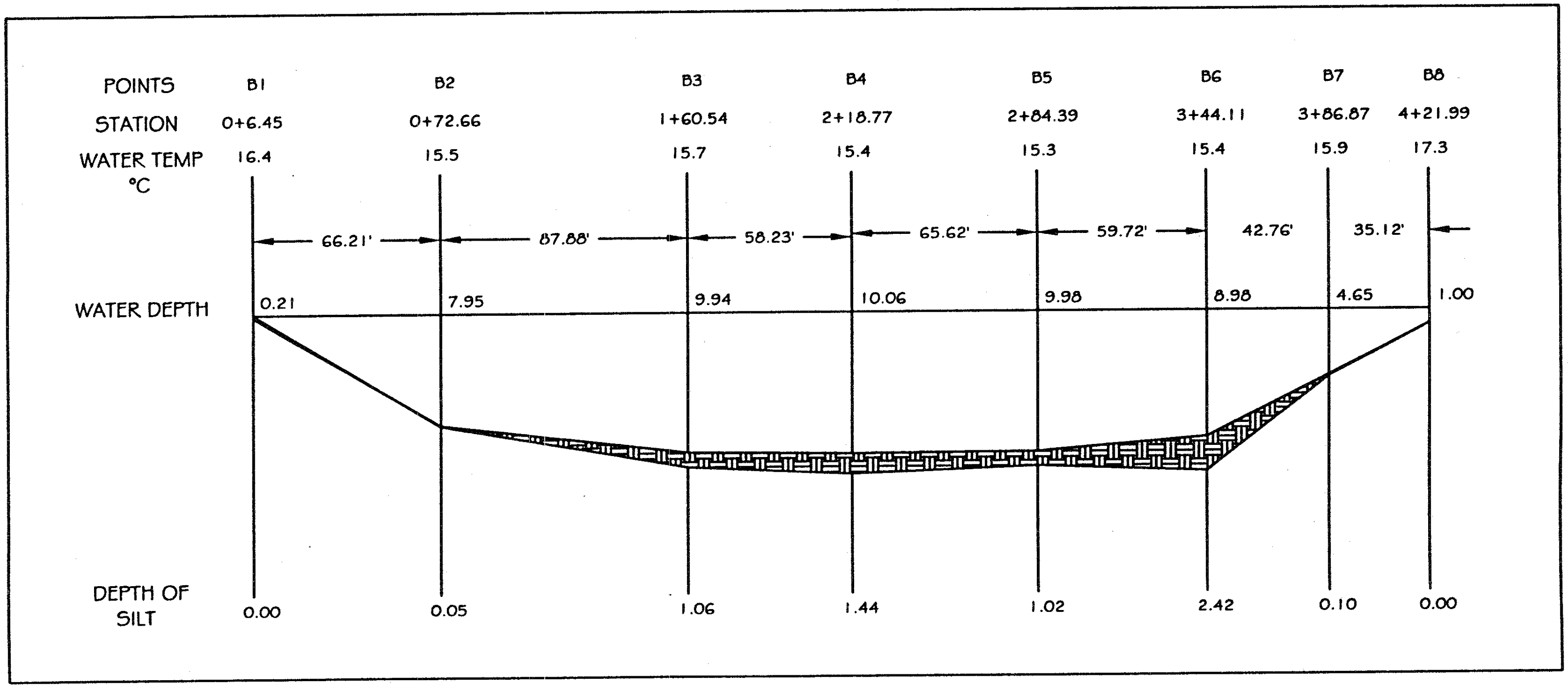
DRAINGAGE AREA:		56 ac./644ac.
RUNOFF CURVE NUM:	83.6/83.9	c=0.47
2-YEAR FLOW:	I=1.8	545cfs
10-YEAR FLOW:	I=2.6	787cfs
100-YEAR FLOW:	I=3.8	1150cfs

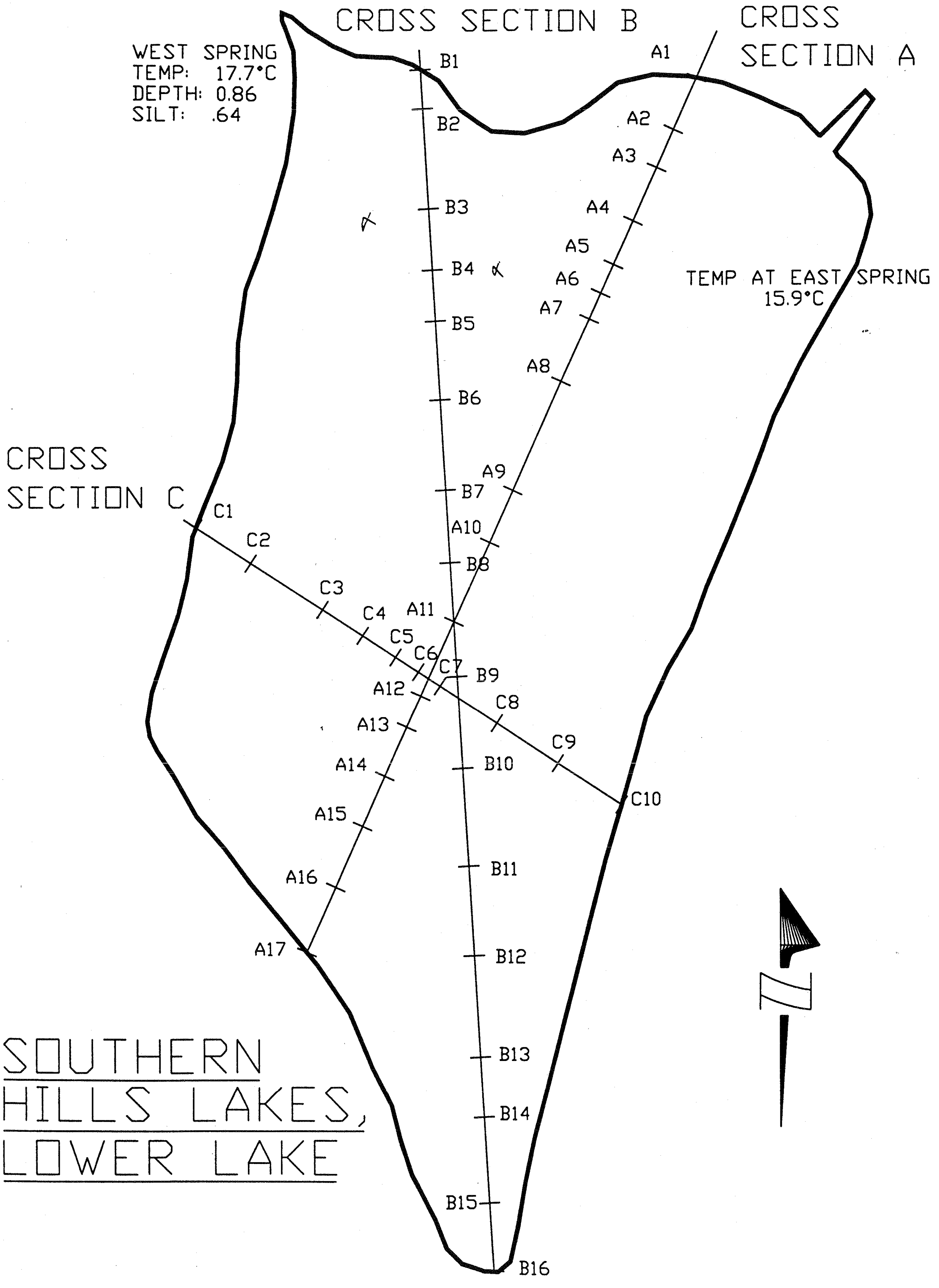
LAKE DATA:

AREA OF SURFACE:	10.39 ACRES.
LENGTH OF FLOW:	983.64 FT.
MEAN DEPTH:	5.63 FT.
DEEPEST POINT:	9.50 FT.
VOLUME OF WATER:	38.08 ACREFT.
VOLUME OF SILT:	8,757.94 C.Y.
MEAN WIDTH:	389.55 FT.
MEAN SEDIMENT DEPTH:	.93 FT.
SPILLWAY DIMENSIONS:	4.5'x2.2' (3)
SPILLWAY CAPACITY:	119 cfs

SOUTHERN HILLS, MIDDLE LAKE

CROSSECTION B

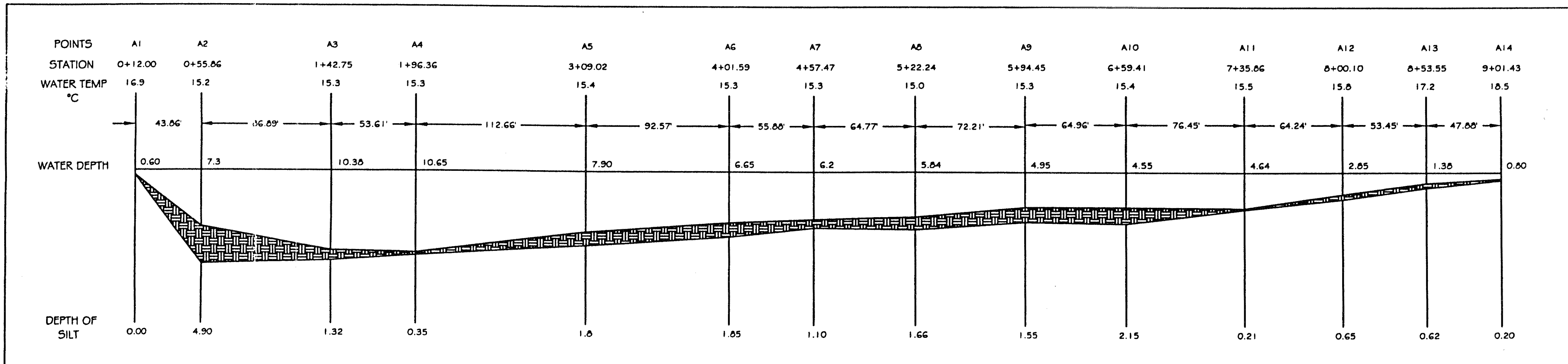




SOUTHERN HILLS LAKES, LOWER LAKE

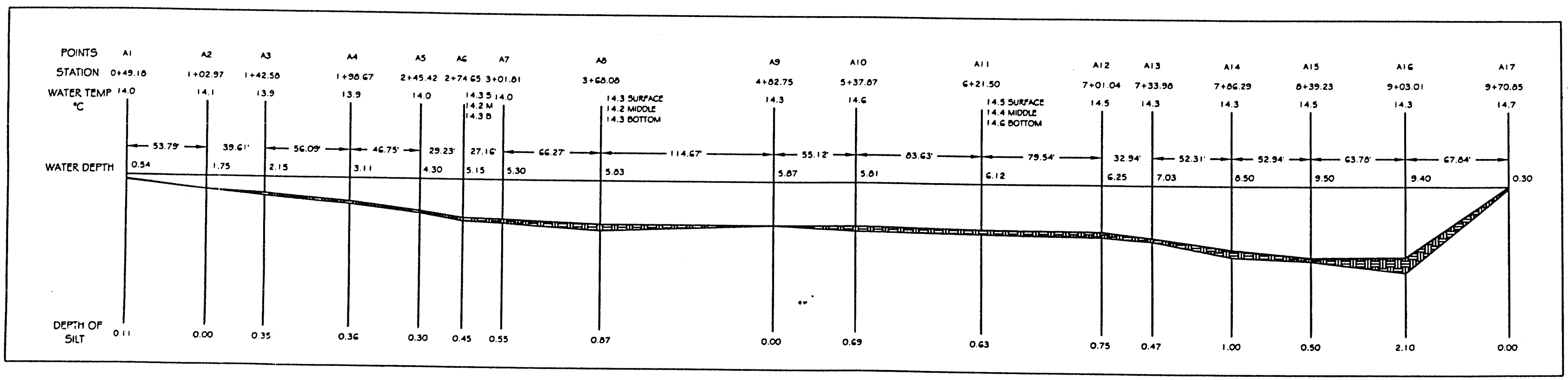
SOUTHERN HILLS, MIDDLE LAKE

CROSSECTION A



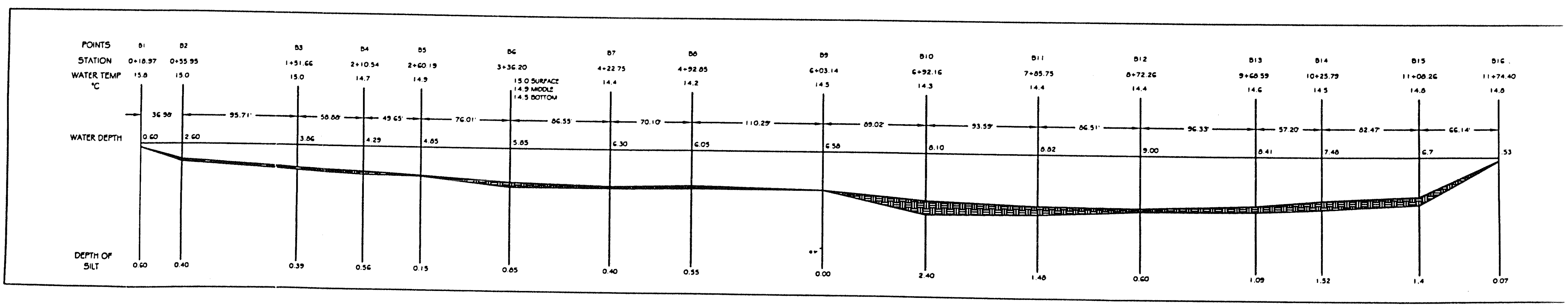
SOUTHERN HILLS, LOWER LAKE

CROSSECTION A



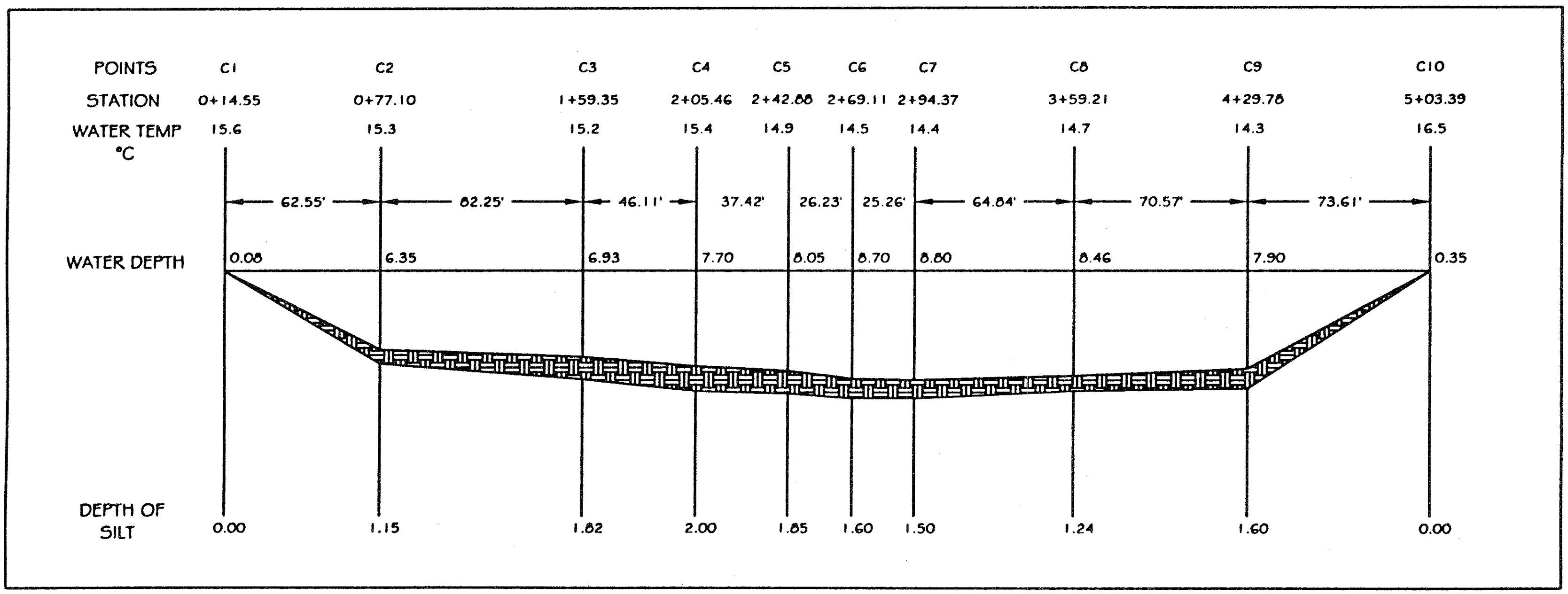
SOUTHERN HILLS, LOWER LAKE

CROSSECTION B



SOUTHERN HILLS, LOWER LAKE

CROSSECTION C



APPENDIX E

Baseline Spring Sediment Analysis
Heather Rache
SMSU GGP & Chemistry Departments
Watershed Committee of the Ozarks

	sample	As	* Ag	Ni	Ba	Al	Co	*Mn	Cr	Mg	V	Ca	Zn	*Cu	Pb	Cd
	name	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SPRING →	Southern Hills 1	23.8	0.2	16.9	109.9	12517.0	8.4	123.0	47.2	647.8	46.9	15465.4	64.3	11.2	43.7	1.3
BANK →	Southern Hills 2	24.1	0.7	20.3	312.9	15353.2	14.9	38.8	44.0	845.4	48.0	14996.1	74.6	12.4	63.0	NA
LAKE →	Southern Hills 3	21.6	0.0	14.9	109.6	15911.9	6.0	70.0	23.1	939.6	31.5	51892.9	104.1	24.3	42.2	NA
	Sequiota 1	30.7	0.7	21.2	121.6	26621.6	3.4	39.3	38.8	1614.6	37.5	50097.4	130.6	15.8	37.8	0.7
	Sequiota 2	24.2	0.8	16.8	152.9	19486.9	3.5	13.9	24.6	1170.9	33.0	16859.2	108.4	14.8	33.0	NA
	Sequiota 3	27.5	0.9	20.3	137.1	24189.3	4.6	34.6	30.3	1395.4	36.2	21371.0	119.5	17.8	43.6	1.1
	ERM	85	2.2	50					145				270	390	110	9

* questionable ICP readings based on known spring data from other locations
ER-M median effected via NOAA

Note to user
These are preliminary readings! Duplicate tests have not been run. This analysis had a standard stock solution used, but not a USGS standard. The USGS standard will be used in the following weeks.

APPENDIX F

-----Original Message-----
From: Wilson Hydro [mailto:wilsnh20@rollanet.org]
Sent: Friday, December 22, 2000 4:20 PM
To: Mike Giles; Todd Wagner
Subject: Southern Hills Lakes

Mike & Todd,

I have run the Southern Hills watershed HEC-1 model with a 3, 6 and 12-hour
storm and have the following results:

Upper Lake

3-hour, 2-year 15% reduction (outflow is 15% less than inflow), 100-year 2%
reduction
6-hour, 2-year 12% reduction, 100-year <1% reduction
12-hour, 2-year 8% reduction, 100-year <1% reduction

Middle Lake

3-hour, 2-year 28% reduction, 100-year 1% reduction
6-hour, 2-year 13% reduction, 100-year <1% reduction
12-hour, 2-year 6% reduction, 100-year <1% reduction

Lower Lake

3-hour, 2-year 38% reduction, 100-year 26% reduction
6-hour, 2-year 29% reduction, 100-year 11% reduction
12-hour, 2-year 16% reduction, 100-year 3% reduction

Cumulative effect

3-hour, 2-year 56% reduction, 100-year 13% reduction
* 6-hour, 2-year 33% reduction, 100-year 10% increase *
12-hour, 2-year 12% reduction, 100-year 21% increase

Note: 6 hour, 100 year event is regulatory flood, as per City staff.

In general, the lakes provide a greater peak reduction benefit for the shorter duration, lower volume storms. The effectiveness decreases as the storm duration and volume increase. Please note that the storage is insufficient to offset the increase in accumulated drainage area for extended duration storm events resulting in an increase in peak discharge from the lower lake as compared to the inflow to the upper lake.

I can verify a 24-hour storm if you need it. Let me know if there is anything else I can do.

Joseph P. Wilson, P.H., P.E.
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Rolla, MO 65401
1-800-994-9487
http://www.wilsonhydro.com
wilson@wilsonhydro.com